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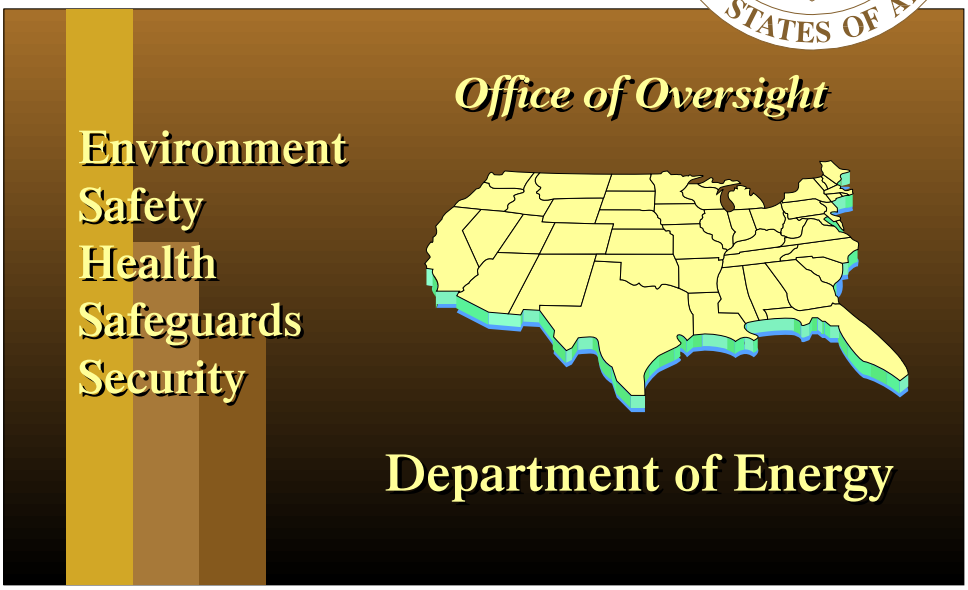
OVERSIGHT

Independent Oversight Followup Review of the

Status of Groundwater Tritium Plume Recovery Activities at the

Brookhaven National Laboratory

October 1997



Office of Environment, Safety and Health

Executive Summary

EVALUATION:	Office of Oversight Review of Groundwater Tritium Plume Recovery Activities
SITE:	Brookhaven National Laboratory
DATES:	August 1997

Scope

This DOE Office of Oversight followup review strictly focused on the effectiveness of DOE and BNL efforts to identify and eliminate the source of the tritium leak and mitigate the tritium groundwater plume at the Brookhaven National Laboratory (BNL) High Flux Beam Reactor (HFBR). This followup review is one part of an ongoing DOE Office of Environment, Safety and Health (EH) effort to ensure that the tritium contamination problem is successfully resolved. Previous efforts included the Interim Evaluation of Tritium Plume Recovery Activities at BNL and the Integrated Safety Management Evaluation of BNL, which were completed in February 1997 and April 1997, respectively.

Results

Significant progress is being made toward the identification and remediation of the tritium plume. Specific accomplishments include:

- Three of four HFBR spent fuel shipments have been completed. The final shipment is scheduled for September 1997. Completing these shipments is a prerequisite to emptying the fuel pool, which is necessary to eliminate continued leakage and to upgrade the pool to prevent leaks in the future.
- All fuel has been removed from the reactor vessel.
- The leading edge of the tritium plume is being pumped to the recharge basin, and volatile organic compounds are being removed
- Air monitors have been installed at the recharge basin.
- Additional wells, including 74 vertical profile wells and 36 of a planned 38 permanent groundwater monitoring wells, have been installed to profile and monitor the tritium plume.
- Conceptual design has been completed for a stainless steel liner and leak detection system for the HFBR fuel pool.
- Reactor building penetration seals and floor joints are being upgraded and measures to provide additional containment for embedded HFBR process piping are being implemented.
- The HFBR safety analysis report (SAR) is being revised to meet existing standards.
- The remediation efforts have been formalized to a project with an approved baseline.
- A Nuclear Regulatory Commission license amendment for the third and fourth spent fuel shipments will be obtained.
- The supplemental environmental impact statement that was approved to ship spent fuel is less than one year old.

These accomplishments reflect current strong project leadership and significant staff efforts within both the DOE Brookhaven Group (BHG) and BNL. These recent accomplishments have been made possible through a coordinated and cooperative effort between DOE Headquarters (including the Offices of Energy Research; Nuclear Energy, Science and Technology; Environmental Management; and Environment, Safety and Health), the Chicago Operations Office, and BHG,

regulators, legislators and BNL stakeholders. Such cooperation has been essential in meeting many challenges and requirements associated with the plume recovery, including allocation of funding, procurement of materials, installation of wells, analysis of samples, and accelerated review and approval of proposed actions and permits necessary to ship fuel and to characterize and pump the tritium plume.

In addition to actions directly related to the tritium plume, BHG and BNL have also completed or are in the process of completing improvements in other aspects of their environmental protection program, based on lessons learned while responding to the tritium contamination. They have completed the first phase of an environmental vulnerability review of other BNL facilities; this effort has identified significant issues that need to be resolved. In addition, the funding for the BNL groundwater monitoring program has been increased and BNL has installed groundwater monitoring wells near active facilities that were not previously covered by environmental restoration monitoring.

Although much progress has been made, many key activities remain to be accomplished, including draining the spent fuel pool, installing the spent fuel pool liner, completing modifications to HFBR, completing the SAR revision, and selecting a long-term alternative for plume management. These activities are being performed according to established plans and schedules, which have been appropriately reviewed and modified as necessary to achieve the intended objectives. The Office of Nuclear Energy, Science and Technology has recently reaffirmed its commitment to revise the SAR on schedule to support HFBR.

Conclusions

Current management of the BNL tritium remediation project is effective, and progress has been substantial. Continued attention is needed to ensure that ongoing activities are completed on schedule in the face of a number of upcoming challenges, such as potential funding and staff reductions, the upcoming transition of contractors, and the need to devote resources to issues identified by the environmental vulnerability assessment and other groundwater contamination discoveries.

1.0 Introduction

In January 1997, groundwater samples taken from recently installed monitoring wells south of the Brookhaven National Laboratory (BNL) High Flux Beam Reactor (HFBR) indicated tritium levels in excess of the Environmental Protection Agency (EPA) limits for drinking water. The HFBR remains shut down pending completion of a process established by the Secretary of Energy to seek stakeholder input to assist in the decision on the future of HFBR.

On January 27, 1997, the Assistant Secretary for Environment, Safety and Health (EH) dispatched a team to perform an independent oversight evaluation of the Department of Energy (DOE) and BNL activities related to the recovery from tritium contamination in the groundwater. The January 1997 evaluation was followed closely by an Office of Oversight integrated safety management evaluation at the Brookhaven Site.

The Office of Oversight conducted a followup review of groundwater tritium contamination at the BNL HFBR.

The Office of Oversight has committed to continue to follow the DOE and BNL tritium remediation activities to ensure that the tritium contamination problem is successfully resolved. Accordingly, Office of Oversight personnel review key documents on an ongoing basis and periodically visit the site to evaluate progress. As one part of the ongoing followup effort, Oversight sent a team of technical specialists to BNL August 19-21, 1997, to review progress by DOE and BNL. The Oversight followup review team focused on the effectiveness of DOE and BNL in identifying and eliminating the source of the tritium leak and mitigating the tritium groundwater plume at the HFBR. Although focusing primarily on the DOE and BNL efforts related directly to the HFBR tritium plume, the Oversight team also reviewed related DOE and BNL groundwater monitoring and environmental protection initiatives.

This report is intended as a complement to the February 1997 Office of Oversight report entitled *Interim Report on the Office of Environment, Safety and Health Oversight of Groundwater Tritium Plume Activities*, which documents the results of the initial independent oversight review of the groundwater tritium contamination. The February 1997 report provides background information about BNL, the HFBR, the history of the efforts to install monitoring wells, tritium and its health effects, other environmental remediation efforts at BNL, and the initial efforts to characterize and eliminate the leak and determine how to remediate the plume. As discussed in the February 1997 report and the subsequent integrated safety management evaluation report, weaknesses in safety management programs at BNL contributed to delays in detecting groundwater tritium contamination at the HFBR.

Horizontal Drilling To Detect Contamination beneath the Fuel Pool at the High Flux Beam Reactor

Although this report focuses exclusively on the safety management issues related to tritium groundwater contamination at the HFBR, EH is also continuing to follow up on other identified safety management issues through other means.

This followup review includes an assessment of DOE and BNL progress on the key elements of the tritium remediation effort, including:

- Project management
- Source management and HFBR modifications
- HFBR tritium plume characterization and mitigation
- Groundwater and environmental management systems.

The last item in the above list addresses actions taken specifically in response to the HFBR tritium plume and the broader effort to improve groundwater management and environmental monitoring on a sitewide basis.

2.0 Project Management

Background

As identified in the February 1997 Office of Oversight interim evaluation, there were some concerns about coordination among DOE Headquarters, the Chicago Operations Office (CH), BHG, and BNL during the early phases of the recovery project. Many issues were being addressed and key decisions were being made regarding important project initiatives such as source identification and remediation, placement of additional monitoring wells, and plume mitigation and remediation. However, DOE and BNL were not using a systematic project approval process to ensure that decisions made and options selected were in the best interests of the Department, BNL, and the stakeholders. The February interim evaluation of the BNL HFBR identified several opportunities for improvement related to these concerns. The February evaluation also identified a need to expedite planning for eliminating the tritium source and mitigating the plume and to apply lessons learned to improve environmental management across the site.

DOE and BNL managers developed plans to address the tritium contamination.

In February 1997, BHG and BNL restructured the project recovery team and revised the project plan to facilitate a systematic approach to project management and key decisions. The DOE Headquarters support was also strengthened through onsite presence and involvement of the Assistant Secretary for EH; the Director of the Office of Nuclear Energy, Science and Technology (NE); and the Director of the Office of Energy Research (ER). CH developed an action plan to respond to the February 1997 Office of Oversight interim evaluation based on the opportunities for improvement contained in the report. This CH action plan was subsequently integrated into the "DOE Action Plan for Improved Management of BNL" developed by ER in response to the interim evaluation and the subsequent integrated safety management evaluation.

Results

DOE and BNL are managing the efforts to identify and eliminate the source of the tritium leak and mitigate the tritium groundwater plume through the tritium remediation project. Management of the tritium remediation project presents a significant challenge to DOE and BNL and requires considerable resources and funding. For example, the project involves expediting procurement of equipment, drilling wells, analyzing numerous samples, obtaining regulatory approvals and permits, and accelerating shipment of HFBR spent fuel across state lines.

DOE senior managers are providing direction to the tritium remediation effort.

To successfully cope with these challenges, the project has been reorganized several times with the current alignment illustrated in Figure 1. The tritium remediation project is managed by a team led by a BHG project manager and consists of BNL managers and staff. A key factor in focusing senior management attention and DOE resources to improve project management was the Secretary of Energy's action to bring senior managers from other sites to lead the BNL effort. These managers have been reporting directly on the efforts to implement the project. DOE Headquarters (including ER and NE), CH, BHG,

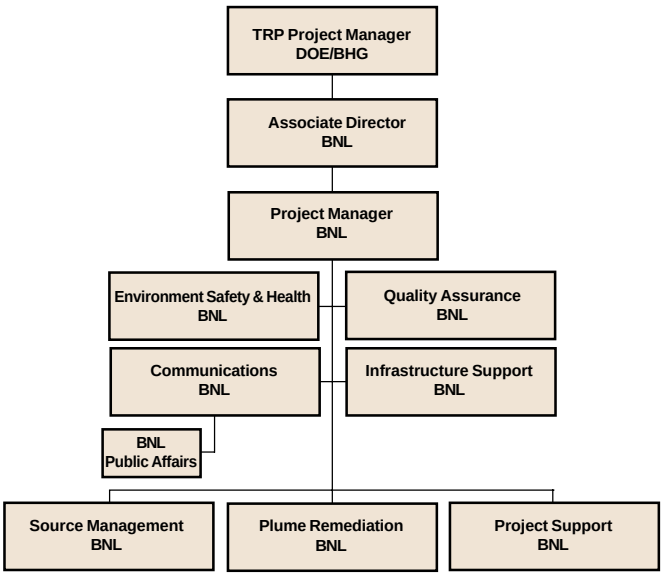


Figure 1. Tritium Remediation Project Management Team

and BNL senior managers provide direction to the tritium remediation project team.

The tritium remediation project is divided into two groups of project activities: source management and plume remediation. A project support organization provides support to the two working groups. Specific project activities assigned to each of the two groups are listed in Figure 2.

Other key activities related to this tritium remediation project include:

- A facility-by-facility environmental vulnerability review by DOE and BNL
- Improvements in management and funding of the groundwater monitoring program for active facilities

Source Management

- HFBR Article 12 (Suffolk County Sanitary Code of Hazardous Materials Storage and Handling Control) upgrades
  - Embedded single-walled piping upgrades
  - Stack drains upgrade
- Fuel pool liner
  - Conceptual design complete
  - Liner & leak detection systems
- Fuel pool water management
  - Decontamination & decommissioning plan
  - Procurement of new storage tanks
  - Onsite storage control rod blades
- HFBR equipment level floor joints and penetration repairs
  - Seal material replacement
  - Replace floor joints
- Fuel shipments
  - 3 of 4 fuel shipments completed
  - DOE approval of supplemental analysis (complete)
  - NRC approval of shipping container amendment (complete)
  - All fuel out of reactor
- HFBR upgrade
  - DOE Order 5480.23, “Nuclear Facility Safety Analysis”
  - DOE Order 5480.30, “Nuclear Design Criteria”
- HFBR source identification
  - Leak rate testing
  - fuel pool
  - Horizontal drilling
  - Identification HFBR effluents and monitoring
- HFBR transition planning
  - Transition modification plan
  - Basic Energy Sciences Advisory Committee review (complete)
  - Public outreach meetings
  - DOE decision on restart or deactivate
  - Cost and schedule review

Plume Remediation

- Plume profile
  - Plume map redrawn
  - Characterization of west side of plume
  - Tritium compilation report
- Vertical profile wells (74)
- Permanent well installation
- Plume sampling & analysis
  - Analysis: full range radioisotopes and VOCs
- Pumping of leading edge of plume
  - 120 gpm pumping
  - 3 extraction wells
  - Carbon filters removing VOCs
  - Recharge basin monitoring wells installed
- Air monitoring plan
  - Recharge basin air monitors installed
- Evaluation of long-term alternatives
  - Institutional controls
  - Containment
  - Discharge
  - Evaporation
  - Monitoring (equilibrium)

Figure 2. Tritium Remediation Project Activities

- Response to additional groundwater contamination findings and events, including:

  - Pile fan sump contamination
  - Brookhaven Medical Research Reactor (BMRR) groundwater contamination

- EPA Multi-Media Review

  - Phase I - Regulatory Compliance Assessment
  - Phase II - Process Waste Assessment
  - Phase III - Environmental Management System Review

Additional information on the management and status of the tritium remediation project efforts is included in the applicable sections of this report.

CH has been supportive of the facility-by-facility vulnerability review conducted at BNL. By arranging for review team representatives from other DOE laboratories, CH increased the experience of the review teams and provided a mechanism for carrying lessons learned back to these other laboratories. At the present time, CH is not actively engaged in management of the tritium remediation project but has provided appropriate technical support to BHG on request.

DOE and BNL have made substantial progress in resolving the tritium plume problem.

DOE and BNL have made substantial progress on the identification and remediation of the HFBR tritium groundwater plume since the February 1997 Office of Oversight interim evaluation. The status of the project is communicated with DOE, BNL, regulators, and stakeholders through weekly status meetings and reports, monthly project reports and stakeholder and employee outreach programs. Tritium remediation project accomplishments completed since January are identified in Figure 3.

These accomplishments have been completed on schedule, and additional planned actions are proceeding on schedule. Ongoing actions include preparations to drain and line the spent fuel pool to eliminate the tritium leak source and to manage the groundwater tritium plume. The HFBR and the reactor building are being modified to prevent any potential additional leaks.

- **Three of four HFBR fuel shipments complete (last shipment is scheduled for September)**
- **All fuel removed from the reactor**
- **Leading edge of the plume being pumped to recharge basin**
- **Air monitors installed at the recharge basin HFBR**
- **Safety analysis report revision is in progress**
- **Plume profile map redrawn**
- **74 vertical profile wells installed**
- **36 of 38 permanent wells installed**
- **Spent fuel pool liner and leak detection system conceptual design complete**

Figure 3. Key Project Accomplishments

Assessment of Project Management

Both DOE and BNL are providing strong leadership to the tritium remediation project. Schedule milestones and objectives are generally being met, and some activities are ahead of schedule. The environment, safety and health (ES&H) and quality assurance (QA) representatives on the project have been elevated to report directly to the project manager. Interviews indicate that project management as well as DOE and BNL senior management have been very responsive to ES&H and QA issues related to the project.

A cooperative effort by DOE, BNL, regulators, and stakeholders has contributed to progress on the tritium remediation effort.

The success of the tritium remediation project to this point is attributable to an effective and cooperative effort between DOE, BNL, legislators, regulators, and stakeholders and the hard work of the dedicated staff within BHG and BNL. Regulators, including the Nuclear Regulatory Commission (NRC), the EPA, the Suffolk County Department of Health Services (SCDHS), and the New York State Department of Environmental Conservation (NYSDEC), have been particularly supportive of the project through the accelerated review and approval of proposed actions and permits. This cooperation was demonstrated through the accelerated approval and implementation of the shipments of HFBR fuel, and approval of the

tritium plume pumping system. This exceptional coordination and cooperation between all parties associated with this project should be improved even more by the recent formation of the Brookhaven Executive Round Table. This committee, which includes regulators, stakeholders, and community members, presents a forum for frequent, routine, and executive level communications about BNL and integration of activities related to BNL with the community.

Overall, the management of the tritium remediation project has been effective, and progress has been substantial. However, there are a number of upcoming challenges that require continued DOE and BNL attention:

- Resolution of significant issues identified by the environmental vulnerability review
- Continuing groundwater contamination discoveries
- Pending change of the operating contractor and related transition costs
- Potential funding reductions for BNL operations
- Potential downsizing of DOE or BNL staff.

These factors have the potential to divert resources and/or management attention from the tritium plume remediation effort. Continued management attention will be needed to manage these challenges and ensure that the tritium remediation effort is completed effectively and on schedule.

3.0 Source Management and HFBR Modifications

Background

BNL is identifying potential sources and making design changes to prevent future contamination.

Source management involves the identification of potential sources of tritium from within the HFBR and developing modifications to prevent further releases. The first step was to identify all sources of tritium that could be released from the HFBR to the groundwater. Once these potential sources were identified, BNL was able to begin developing modern designs and modifications to these systems to prevent any releases. The final step of the process is to capture these modifications in the safety analysis report (SAR) revision and the facility operational information to support a decision on the future of the HFBR.

In its February 1997 report, EH identified expedited planning, preparation, and decisions related to tritium plume source resolution as an opportunity for improvement. The opportunities for improvement identified potential actions for DOE and BNL to consider in areas such as spent fuel pool leak detection systems, reduction of spent fuel inventory, source identification and monitoring, and inspections of reactor building seals and floor penetrations.

HFBR Spent Fuel Pool

Results

BNL has applied appropriate resources and completed many actions to identify and mitigate potential sources of tritium.

Since the tritium contamination was identified in December 1996, BNL has completed many initial actions and appropriately addressed many of the opportunities for improvement identified in the February 1997 Office of Oversight interim evaluation report. These actions included preliminary engineering designs, removal of spent fuel from the reactor and spent fuel pool, engineering evaluations, and tests to determine potential sources of leakage. Appropriate project resources are being applied to ensure source identification and correction at the HFBR.

BNL issued the "High Flux Beam Reactor Tritium Source Identification" report on July 31, 1997. This report reviews all activities conducted to date by BNL to identify the source of tritium contributing to the plume emanating from the HFBR building. Source identification activities consisted of evaluating sources of tritium that have the potential to release tritium into the environment. Leak tests were conducted where appropriate to determine the integrity of each of the potential sources containing tritium. Table 1 summarizes actions taken by BNL and the results.

Table 1. High Flux Beam Reactor Tritium Source Identification, Evaluation, and Resolution Conducted by Brookhaven National Laboratory

Potential Source	Description	Results	Actions/Design Improvements to Prevent Possible Releases
Primary coolant purification system piping	Embedded piping in equipment level floor (ELF) from reactor to the pipe trenches	Leak tested at 425 psig during construction. Engineering evaluation.	Flexible stainless steel piping will be inserted into the existing embedded piping and welded. The installation will meet Suffolk County Article 12 requirements. This design provides double wall protection to prevent releases.
Primary coolant purification system trenches	Trenches containing filters and resin beds located northeast of the spent fuel pool	Visual inspection and air leak test. No air shown to be infiltrating at 0.7 inch negative pressure in the reactor building .	Trenches are continuously monitored during operation and do not normally contain tritium.
DA drain, D2O transfer system and FA101 pit	Embedded piping in ELF to drain primary coolant to FA101 tank	Visual inspection and air leak test. No air shown to be infiltrating FA101 pit at 0.7 inch negative pressure in building. Sump filled with water and no leakage observed.	Embedded piping will be rerouted above floor.
CD floor drains	Floor drains in A, B, and shutdown cells routed in ELF FA101 sump	Engineering evaluation. Leak tested at 50 psig during construction.	Additional leak testing planned to demonstrate compliance with Article 12 requirements.
Spent fuel pool water purification system piping	Piping leading to and from the spent fuel pool to the water cleanup system	Supply and return lines isolated and leak tested at 50 psig. No loss in system pressure observed.	Embedded piping to be drained, capped, and abandoned. New piping to be rerouted above the concrete.
D-Waste floor drain piping and sump	Drainage system in ELF for light water process sytems	Engineering evaluation. Leak tested at 50 psig during construction.	Eight different modifications to the system are required to reroute active (wet) drains. System to be reclassified as a dry system when modifications are completed. Drain piping in the floor will remain for emergency use.
Spent fuel pool	68,000 gallon storage pool located on the east side of the reactor core	Two leak tests confirm leakage at a rate of 6 to 9 gallons per day. Visual inspection showed no apparent leakage locations. Horizontal well sampling and analysis inconclusive to date.	Conceptual design completed which indicates that a double walled stainless steel insert with leak detection is the best method for eliminating further releases from the spent fuel pool.
Equipment level floor seams and other perforations	Drains, penetrations, and seams in A, B, and shutdown cell. Also CD cleanout drain near B cell	Leak testing apparatus developed for static water leak tests. Leakage occurred at some locations in A, B, and shutdown cell. CD cleanout drain grouting accepted water at a rate of 1 liter in 9 minutes.	Floor seams will be repaired utilizing a foam impregnated waterproof polymer sealed with a urethane epoxy sealer. Floor seams and penetrations will be entered into the routine surveillance program to ensure integrity.
Sanitary system piping	Embedded piping runs around circumference of equipment level floor	Historical tritium concentrations managed in sanitary system have been less than the highest concentrations seen in the plume. Waste streams containing tritium are no longer sent to sanitary sewer system.	Rerouting of waste streams minimizes the tritium in the sanitary water.
Secondary cooling water systems	Primary coolant routed to heat exchanger for heat removal	Secondary coolant continuously monitored and no leakage has been observed.	Continuous monitoring is required for operation.

Based on two separate leak-rate tests, the BNL report concluded that the spent fuel pool is the most likely source for the tritium contamination in the ground water. Concentrations of tritium in the spent fuel pool water are consistent with the concentrations observed in the plume emanating from the HFBR building.

In April 1997, two horizontal wells were installed near the spent fuel pool underneath the reactor building. These wells were placed in the water table to the north and south of spent fuel pool (groundwater flows generally from north to south) in an attempt to confirm the spent fuel pool as the source of the tritium. The results from these wells has been inconclusive so far because of the wells' location in the aquifer (i.e., seasonal variation in the water table level has made it difficult to obtain representative samples). However, BNL expects to obtain more representative samples in the next few months as the water table levels undergo their normal seasonal changes.

BNL is well on the way to having all spent fuel shipped off site, which will allow draining of the spent fuel pool.

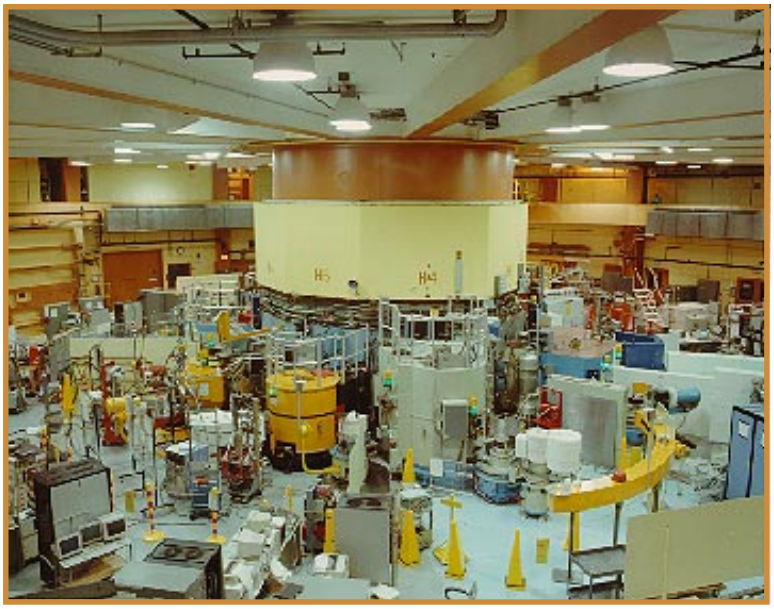
BNL has completed three of four fuel shipments. The fourth shipment is in progress and is expected to be complete by mid-September. This action will complete the removal of spent fuel from the spent fuel pool, which is a prerequisite to pumping out the pool and eliminating the most likely tritium source. The accelerated fuel shipment schedule was accomplished in coordination with the NRC. Specifically, NRC reviewed and approved an amendment to the shipping container license; approval of this amendment was a prerequisite for two (the third and fourth) of the four shipments.

A decontamination and dewatering plan for the spent fuel pool was prepared. It is being revised by the project team to add information and improve the approach to pumping out the fuel pool. The plan outlines the steps necessary to remove the activated components and contaminated equipment from the pool, dewater the pool, and decontaminate it. The plan relies on the installation of two new 20,000 gallon tanks combined with an existing 25,000 gallon tank in Building 811 to accept the spent fuel pool water. The existing tank is currently full of contaminated water; it must be emptied to support draining the spent fuel pool. BNL is starting up an evaporator to assist in processing the current inventory of contaminated water. The spent fuel pool is scheduled to be pumped out in November 1997.

BNL conducted an engineering evaluation to identify suitable material to replace the sealant between the building floor joints and penetrations. The existing sealant has exceeded its design life and will be removed, and the affected areas will be cleaned. An open-cell, foam-impregnated, waterproof polymer will be used to seal the seams. A second coating of urethane epoxy sealer will be applied over the polymer to provide another leak-tight seal. Repairs are scheduled to begin in October 1997. A procedure for inspecting the seals is being developed and will be incorporated into the surveillance and maintenance programs at HFBR.

In conjunction with source identification and engineering analysis, BNL has prepared the HFBR Transition Plan, which outlines the necessary steps to modify the reactor to support a Secretarial decision on the future of the HFBR. The plan also outlines the key elements necessary to support the future of the HFBR once all of the modifications are complete. Implementation of this plan is contingent upon the Secretary's decision regarding the future of the HFBR.

High Flux Beam Reactor Experimental Floor



The HFBR safety analysis report is being revised to meet current standards.

One issue related to the future of the HFBR involves revising the HFBR SAR to meet current standards and requirements. CH and BNL consider modifying the SAR to be a necessary component to support the future of the HFBR. Work on the SAR revision began on April 1, 1997, using the SAR implementation plan approved by DOE in December 1996 as general guidance. A draft SAR is scheduled for submittal to DOE in December 1998. The SAR modification work is performed by in-house Reactor Division staff who are knowledgeable about the operating history, existing design, and current requirements. The revision is being performed as an integrated project, with a dedicated project manager and specific tasks. Criteria requirements include reformatting, updating, modifications, and comparison with 5480.30, "Nuclear Reactor Safety Design Criteria."

NE's commitment to and expectations for the safety analysis report revision have not been clearly communicated.

Although CH and BNL understand the scope and necessity of the SAR revision, there are some concerns regarding the communication and understanding of NE's commitment at the site level. NE has recently reaffirmed to EH its commitment to revise the SAR on schedule. However, clarification is needed at each organizational level to establish consistency in expectations for transition, funding, and the review and approval process.

The DOE orders pertaining to SARs and reactor design require a rigorous, detailed, and systematic approach to hazard and accident analyses that includes worker safety. They also require technical descriptions and evaluations of the adequacy of safety systems and components included as design features. These orders further require existing reactors, such as HFBR, to evaluate the adequacy of their safety basis against the spent fuel pool performance and design criteria requirements. NE needs to ensure that commitments to address these requirements are clearly communicated. The Office of Oversight will continue followup reviews of the SAR revision process.

Assessment of Source Management and HFBR Modifications

Although continued attention is needed, DOE and BNL have made significant progress in eliminating sources of tritium contamination.

Significant progress has been made in evaluating potential HFBR tritium sources and developing preliminary designs to prevent further releases. These designs will enable HFBR to meet regulatory requirements to support HFBR's future. The Project Manager for Source Management is proactively addressing issues and developing solutions for source management within the HFBR. The removal of spent fuel from the spent fuel pool has accelerated the schedule for eliminating the source of tritium in the groundwater. Continuing management vigilance and resourcefulness will be essential to assure that challenges, such as funding and resource reductions or discovery of additional groundwater contamination, do not adversely impact essential activities such as fuel pool pumping and liner installation, HFBR modifications, or the SAR revision.

4.0 HFBR Tritium Plume Characterization and Mitigation

Background

In its February 1997 interim report, EH indicated a need for expedited planning, preparation, and implementation of mitigation and remediation actions to address the tritium plume. The intent of this expedited planning and implementation of plume characterization and interim remedial action was to minimize the amount of tritium contamination that could reach the southern boundary of the laboratory site.

Results

BNL has an aggressive program to mitigate the tritium plume.

BNL has implemented an aggressive, multifaceted project to address characterization of the plume and mitigation of the contamination. The program includes the following key project elements: (1) determine the profile of the plume, (2) perform groundwater sampling and analysis to support plume characterization, (3) install permanent monitoring wells to allow monitoring of plume mitigation, (4) design and implement an effective interim remedial action, and (5) identify and evaluate alternatives and then design and implement a long-term remedial action. BNL has succeeded in assembling an effective project team that has mobilized substantial resources to complete key project tasks.

Wells have been installed to help determine the extent of the contamination.

The plume characterization efforts have led to a refined interpretation of the horizontal and vertical extent of the tritium plume. The most recent plume map (Figure 4) is based on data that has been compiled to date. This map shows that the plume splits or is partitioned into an eastern and a western lobe. The southern portion of the plume is believed to split because of rainwater entering the aquifer from the recharge basins that are located on Weaver Avenue. The location of the end of each lobe is not exactly known, but existing well data have enabled a reasonable approximation of their extent. Seventy-four vertical profile wells have been installed to characterize the plume; one well remains to be installed.

In addition to determining the lateral extent of the plume, interval sampling in the network of vertical profile wells has enabled a determination of the vertical variability of tritium concentration within the plume. This information has helped to determine the correct placement of the screen intervals for the three tritium plume extraction wells. The extraction well screens have been placed in the highest concentration areas of the plume along Princeton Avenue. Sample data indicate tritium concentrations of about 5500 to 6800 pCi/L in the screened portion of the aquifer at the extraction well locations, which is significantly below the EPA drinking water limit of 20,000 pCi/L.

The nature and extent of contamination along the western side of the plume is still undergoing final characterization. Recent samples indicate that the plume may be wider and more concentrated in the area of the western lobe than was previously thought based on earlier data. Current plans call for the sampling of one more vertical profile well in this area

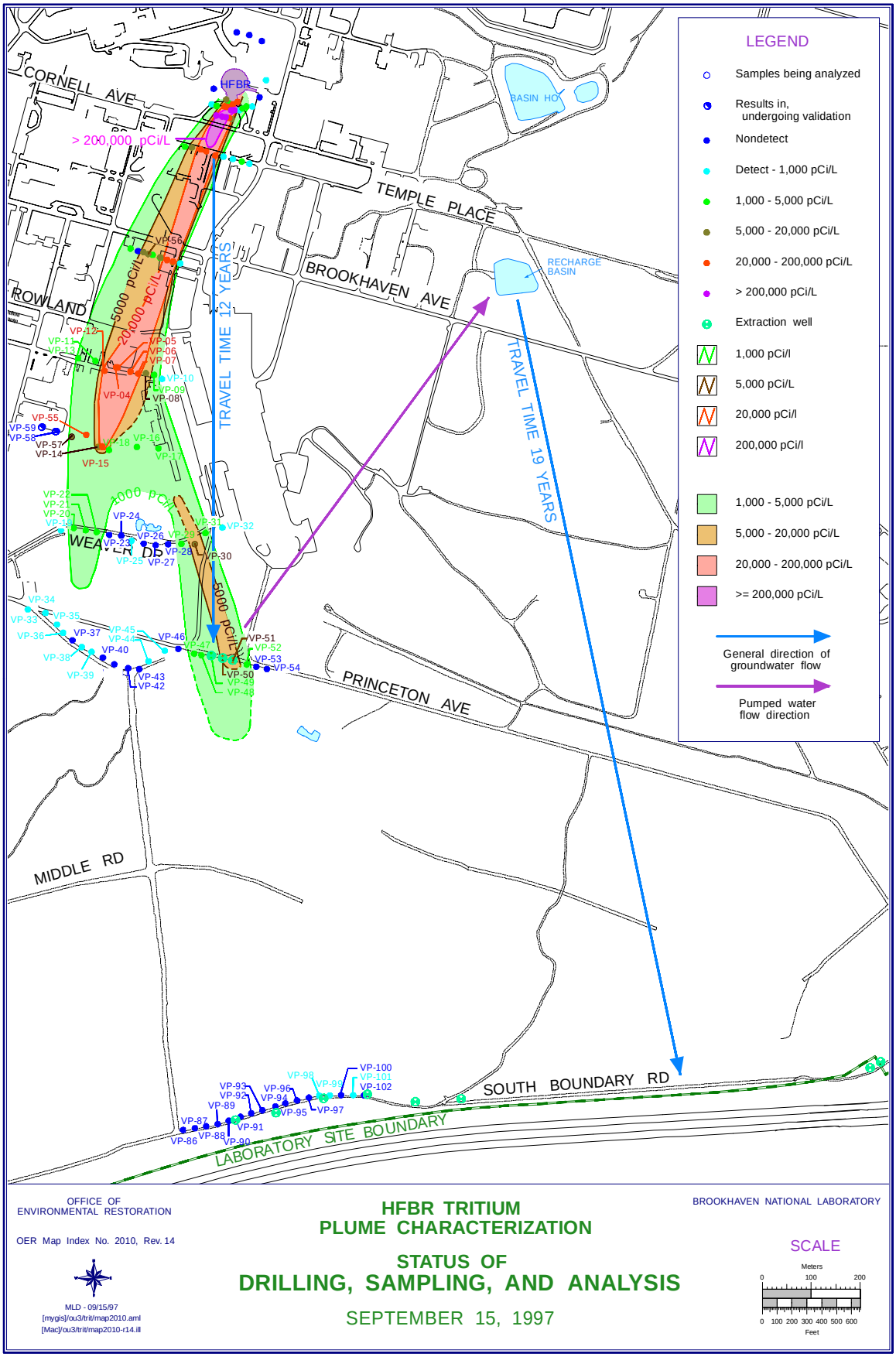


Figure 4. Map of Tritium Plume

before the three permanent monitoring wells are installed. These new wells are intended to provide the data that is needed to resolve uncertainty related to the extent of contamination in this area.

BNL continues to use the numerical groundwater flow and transport model to enhance the understanding, monitoring, forecasting, and implementation of remedial action. As of mid-August 1997, there is an ongoing effort to develop a transient model that reconstructs the history of the tritium plume from the time that the HFBR may have first released tritium into the aquifer, to the present-day plume, as it has been defined by recent vertical-profiling-based characterization. This effort involves accounting for and building into the model a series of transient hydraulic stresses that the aquifer has actually experienced due to temporary operation, over the course of the past 30 years, of various water supply wells and recharge basins in the vicinity of the HFBR. This effort is intended to provide a good understanding of how the plume was generated, and whether other potential sources may have or may still be contributing to the plume. This model will also be used to help evaluate the effectiveness of the interim and various proposed long-term remedial actions.

As of mid-August 1997, 36 of a total of 38 permanent monitoring wells have been installed. These 38 wells will be used, in conjunction with 45 pre-existing permanent wells in this area, to monitor changes in the plume as the interim groundwater extraction and recirculation system continues to operate.

BNL is using extraction wells to pump contaminated water from the plume.

Three extraction wells have been placed along Princeton Avenue to intercept the eastern lobe of the plume about 3800 feet south of the HFBR source. These wells are collectively lifting 120 gallons-per-minute of contaminated groundwater. Selection of their locations, screen intervals, and pumping rates was based on tritium concentrations delineated by vertical profile wells and by capture zone analyses performed using the groundwater flow and transport model. This has resulted in the wells being placed in the most concentrated portion of the plume; however, the extraction pumping causes dilution that lowers the pumped groundwater to less than 1500 pCi/L of tritium. BNL analysis indicates that the extraction rate is not sufficient to cause any increase in the rate of tritium migration above the rate caused by natural southward flow of the groundwater.

Volatile organic compound (VOC) concentrations are also lower than expected in the water being pumped from the extraction wells. The concentration of five of six detected VOC constituents, which are all chlorinated hydrocarbons, are all below 5 ppb. Concentration of the sixth chlorinated hydrocarbon, tetrachloroethene, is less than 50 ppb. As was the case for tritium, these lower-than-expected concentrations result from higher-than-expected dilution during pumping. This simplifies the removal of VOCs by the carbon filters prior to recirculation. The treated groundwater is entering the recharge basin free of any detectable VOC contamination. A series of monitoring wells was installed around the recharge basin that is receiving the water from the extraction wells. Samples from these monitoring wells indicate that recirculation is not significantly impacting groundwater. Modeling indicates that upon recirculation, tritium concentrations in the aquifer are below 1000 pCi/L.

The first of five planned quarterly rounds of groundwater sampling from the permanent monitoring wells is nearing completion. As of August 9, 1997, 77 of 83 wells had been sampled. Samples will be analyzed for tritium, gross alpha and beta and gamma radiation, strontium-90, and VOCs. The remaining four quarterly rounds of samples will be analyzed for tritium and VOCs only.

Long-term remediation options are being evaluated.

BNL continues to evaluate long-term remedial actions to address the tritium plume. Options being evaluated include alternative extraction and recirculation options, institutional controls, containment, detritiation, discharge, and disposal. As the plume becomes better characterized, the decisions regarding the appropriate actions to be taken with respect to long-term remedial action will become clearer.

Assessment of Plume Characterization and Mitigation

DOE and BNL are making progress toward characterizing and mitigating the plume while long-term options are evaluated.

Since the contamination was identified in January, DOE and BNL have made significant progress in characterizing and initiating remedial action for the plume. The project is evaluating the nature and extent of tritium contamination, while concurrently determining an effective and acceptable way to ensure that this contamination will not spread and impact the water supply of the local community. BNL has made progress toward comprehensive characterization of the tritium plume and has installed a large number of monitoring wells to make certain that plume advancement has ceased and that the interim remedial action is working as designed. They are also performing additional groundwater modeling and long-term remediation planning to arrive at the most effective approach to long-term remedial action.

Continued attention is needed to compare actual sample results to those predicted by modeling techniques to ensure adequate characterization of the plume. Although the plume is now fairly well understood, there is not yet direct evidence that plume migration has ceased or that the plume is being effectively captured. Current assumptions are based on predictions from groundwater modeling, analytical results from vertical profile well samples, and general knowledge about groundwater travel time in the aquifer. It will take results from at least two of the five scheduled groundwater samples to accurately characterize the plume, including the western lobe. Other aspects of plume characterization and modeling that warrant continued emphasis include the sample results and modeling techniques, the results of specific groundwater modeling or aquifer pump tests completed to support remedial actions, and the selection process for the long-term remedial action.

5.0 Groundwater and Environmental Management Systems

Background

Weaknesses have been identified in sitewide groundwater and environmental management systems.

During the January 1997 Office of Oversight interim evaluation, weaknesses were identified in the BNL and DOE approach to groundwater management systems involving the tritium plume. The February 1997 interim report identified opportunities to improve groundwater protection and environmental monitoring systems. The opportunities for improvement identified potential actions for DOE and BNL to consider in areas such as sitewide prioritization and location of groundwater monitoring wells, down-gradient monitoring at other BNL facilities identified as containing significant tritium inventories, funding methodologies for the sitewide groundwater monitoring program, and application of lessons learned.

There has been a history of chemical and radiological releases to surface and groundwater on the BNL site. In recent years, the focus has been on addressing high priority response actions to provide public water hookup to homes south of the site, to cap inactive landfills, to remove underground storage tanks, to excavate cesspools, to remove above-ground radiological waste tanks, and to install two groundwater pump-and-treat systems to minimize any additional offsite contamination. In addition to the restoration program, BNL is required by DOE orders to establish an environmental protection program, including effluent monitoring and environmental surveillance. DOE requires monitoring of groundwater that is or could be affected by site activities to determine the effects of operations on groundwater quality and to demonstrate compliance with applicable Federal, state, and local laws and regulations.

Results

Initiatives to improve BNL's sitewide safety management relating to the tritium release include development of a funding request to support a groundwater monitoring program, investigating other sources of tritium, a three-phase EPA review of BNL, and a facility-specific vulnerability study for each facility. These activities are providing feedback and lessons learned that are being shared across BNL's facilities as well as the DOE laboratory complex.

BNL has taken actions to enhance groundwater protection programs.

BNL has increased management focus and support of programs and activities to ensure groundwater protection. BNL has generated funding requests of $500,000 for each of the next two fiscal years to establish a groundwater monitoring program at key research and support facilities to ensure that the potential chemical or radiological leaks will be detected early and to maintain public and regulatory trust in operations. The funding request is supported by a risk-ranking weighting factor that applies a management adjustment factor for considering the potential for site activities to impact the sole source groundwater aquifer. This groundwater monitoring program outlines plans for installation of new wells at the Alternating Gradient Synchrotron, Brookhaven Linac Isotope Producer, Linear Accelerator, Environmental Waste Technology

Center (Bldg 830), Waste Compacting Facility, Relativistic Heavy Ion Collider beam stops, Biology Department, site southern boundary, Chemistry Building, the Sewage Treatment Plant, and the rifle and shotgun ranges. In addition, funding projections have considered the need for additional wells as may be needed in response to other site vulnerability studies. However, implementing these efforts is dependent on DOE funding the BNL Environment, Safety, and Health Management Plan. That plan now defines these activities at the highest priority level. DOE will need to supplement or reallocate funding to support these additional efforts.

BHG and BNL have also demonstrated an increased commitment to environmental protection through aggressively investigating the potential for tritium groundwater contamination at the pile fan sump and the BMRR. These facilities were identified as potential sources of tritium release to groundwater in light of the HFBR investigation. Groundwater monitoring has been initiated at both locations, and the initial sampling indicates contamination. Additional actions are being implemented to fully characterize the extent of contamination, determine the sources and pathways, and review remedial action options. The approach to these new efforts to monitor key facilities and conduct recent investigations is progressing systematically sitewide.

Two other key initiatives have been implemented site wide to identify potential environmental releases at BNL. An EPA Multi-Media Review has been implemented in three phases to assess regulatory compliance, process waste management, and environmental management systems. In addition, a separate comprehensive DOE CH/BHG/BNL facility-by-facility vulnerability study is in progress to review historic and current operations that may impact the environment.

The EPA has communicated results of its Phase I inspection field activities to the Department indicating some potential regulatory noncompliances. EPA Region II continues to request large amounts of related documentation from BHG and BNL in several specific program areas. Phase II efforts involve a review of all chemicals and processes on site in an effort to define a raw material and waste management "mass balance" of site operations, down to the level of individual bench-scale experiments. Phase III is an effort to define environmental management system audit criteria by which future reviews will evaluate Department and contractor implementation compliance. EPA intends to enter into an interagency agreement with the Department defining these management system elements. All of these EPA activities are requiring a significant and increasing level of BHG and BNL management and technical resources as the scope and objectives appear to be expanding.

DOE and BNL are performing a comprehensive review of potential vulnerabilities at BNL facilities.

The sitewide facility-by-facility vulnerability study is a comprehensive process for collecting and analyzing historical and current facility information to identify concerns and corrective actions. Document reviews, retiree and employee interviews, and detailed inspections of the largest (Priority 1) facilities have been completed. Environmental management and technical expertise were provided from several national laboratories to support this effort, at the request of CH. These experts have reviewed documents and inspected facilities to identify potential environmental protection concerns. Some immediate actions and sampling have been conducted to mitigate and quantify potential concerns. The remaining site facilities are being reviewed under the Priority 2 phase of the study. If the envisioned level of effort can be sustained, Phase 2 efforts are scheduled for completion by September 30, 1997.

These efforts have clearly reinforced BNL line management ownership of environmental protection responsibilities. The facility-by-facility vulnerability study requires line managers to collect historical data, inspect current operations, define corrective actions, and maintain an ongoing historical record of activities beyond this baseline effort. Also, the comprehensive review of all BNL facilities has resulted in clearly defined program ownership for all site buildings.

This followup review identified indications of a greater level of openness in communications within BNL, between BNL and other DOE sites, and between BNL and the public. For example, the facility-by-facility vulnerability study has utilized expertise from across the Department's national laboratories, thereby providing an avenue for passing on the lessons learned and corrective actions. Also, BNL is communicating with the Savannah River Site in an effort to share experiences and explore innovations in real time monitoring technology for tritium releases.

Assessment of Groundwater and Environmental Management Systems

Groundwater and environmental management systems at BNL are improving.

The ongoing efforts to actively and proactively manage the environmental protection program at BNL demonstrate significant improvements since the February 1997 Office of Oversight interim report. The installation of groundwater monitoring wells at the BMRR and the ongoing investigation reflect the application of lessons learned from the HFBR experience. Expanding environmental protection efforts to sitewide programs of investigation, monitoring, and corrective actions as a high priority reflects a clear and significant change in management focus.

Maintaining the level of effort and resources to meet the increased emphasis on environmental protection will require a sustained commitment in the short term and substantial increase in commitment of resources in the long term to address newly identified contamination or non-compliances.

The continued stretching of site resources and personnel to meet the demands of the EPA Multi-Media Review and the Phase 2 vulnerability study is rapidly approaching its limits. The inability of the site to respond in a timely manner to EPA information requests and the delays in negotiating the scope of Phase 2 and 3 activities reflect the strain on resources. The EPA Phase 3 negotiations toward an interagency agreement on enforceable environmental management system criteria may have adverse implications for the new BNL contract and across the Department if the criteria are not aligned with the integrated safety management policy (DOE P 450.4, Safety Management System). The negotiations between DOE and EPA need to be actively supported at the Headquarters program office level and the EH Office of Environment.

As the site moves to a more proactive posture by installing monitoring wells at all facilities and continues to aggressively identify additional potential vulnerabilities, a substantial increase in the long-term resource allocation for environmental protection programs may be necessary.

Appendix A
Evaluation Process and Team Composition

The followup review was conducted according to formal protocols and procedures, including an Appraisal Process Guide, which provides the general procedures used by the oversight program for conducting inspections and reviews. The review team collected data through interviews, document reviews, walkdowns, and observation of activities. Interviews were conducted with DOE Headquarters, Brookhaven Group, and Brookhaven National Laboratory personnel, including managers, staff, and technical specialists.

The team membership, composition, and responsibilities are as follows:

Deputy Assistant Secretary for Oversight

Glenn Podonsky

Associate Deputy Assistant Secretary for Oversight

Neal Goldenberg

Director, Office of ES&H Evaluations

S. David Stadler, Director
Michael Kilpatrick, Deputy Director

Team Leader

S. David Stadler

Review Team

Charles Lewis
Chip Lagdon
Pat Worthington
Chris Perry

Quality Review Board

Michael Kilpatrick
Frank Russo
Dean Hickman
Thomas Davis